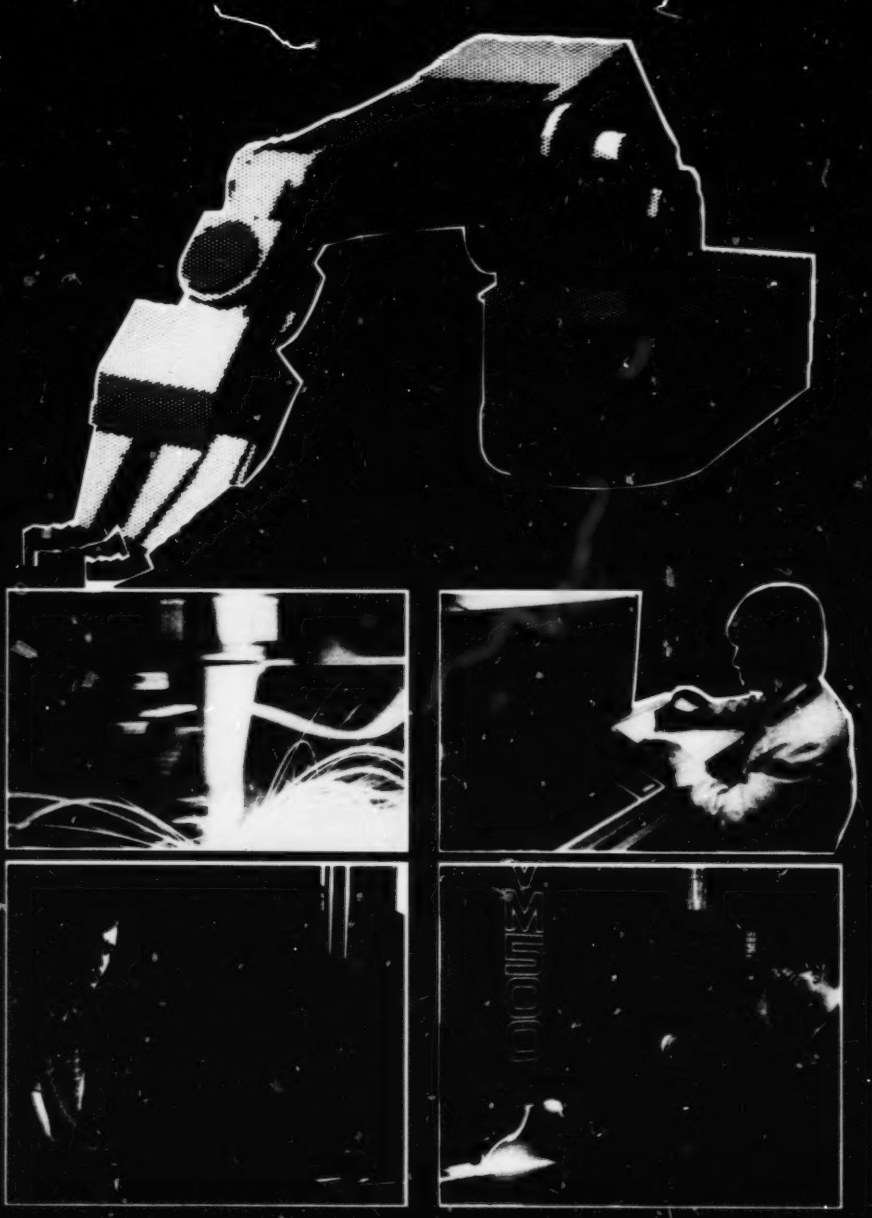
Advanced Manufacturing in Alberta

Needs Assessment Study



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Alberta
TECHNOLOGY, RESEARCH
AND TELECOMMUNICATIONS

ALBERTA
RESEARCH
COUNCIL

Message From The Minister

Technology is altering our world at an ever increasing rate, bringing with it new challenges and new opportunities for everyone. If we are to excel in this competitive and advanced environment, we must plan now for the future.

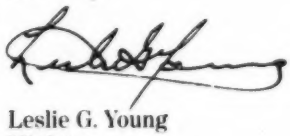
The Government of Alberta is committed to the support and encouragement of advanced technology. Our goal is to place Alberta at the leading edge of worldwide technological development in a number of areas.

It is vital that industry, government and academia work together to develop market niche opportunities in knowledge-intensive industries. The jobs of tomorrow, our long-term economic stability and our standards of living depend on it.

We regard the manufacturing industry as a key area to focus our efforts. In Alberta, it represents a $4.6 billion sector, employing over 80,000 people, and has the potential to contribute significantly to our economy.

The "Advanced Manufacturing in Alberta, Needs Assessment Study" has been undertaken by Technology, Research and Telecommunications and the Alberta Research Council in cooperation with the private sector, to determine the technological needs of the province's manufacturers, and to recommend appropriate means of incorporating advanced manufacturing techniques and product development technologies into this important sector.

Sincerely,



Leslie G. Young
Minister
Technology, Research
and Telecommunications

June, 1987

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Executive Summary

The strength of the Alberta economy has historically been in the natural resource reserves of the province, specifically oil and gas. The provincial government, recognizing the risks associated with an economy based upon the performance of one key industrial sector, has undertaken several initiatives to support diversification. To date, these initiatives have been directed towards the establishment of an advanced technology capability in the province. Recently, in light of declining oil and gas prices, the manufacturing sector has become even more important to the Alberta economy.

Alberta Technology, Research and Telecommunications (TRT) and the Alberta Research Council (ARC) have jointly undertaken Phase I of a two-phased study to assess the needs of Alberta manufacturers to determine the status of manufacturing technology currently used. The study proposes the development of a program or facility to improve the productivity of Alberta manufacturers to enhance their competitiveness in domestic and international markets.

Touche Ross Management Consultants, with the assistance of the Manecon Partnership and the Industrial and Engineering Research Division of the Alberta Research Council, undertook a survey of 99 Alberta manufacturers representing selected sectors, including electronics, machine shops, metal fabrication and wood industries. Representatives of the federal and provincial governments, universities and technical institutes, and selected industry associations were also interviewed, to obtain their perspective on the status of Alberta manufacturers, and to develop an inventory of the supporting infrastructure currently available in industry.

Interviews with selected Alberta companies indicated that although selected companies, particularly in the machine shop and metal fabrication sectors, had made capital purchases of selected advanced manufacturing equipment, the skills and expertise required to make the equipment operational in a fully integrated sense were lacking. As a result, full benefits of the technology are not being realized. In other manufacturing subsectors, there appeared to be a general lack of awareness of the technology and its related benefits. Where there was an understanding of the technology, there was generally a lack of understanding for its applicability to Alberta manufacturing.

A key view often expressed by industry, and clearly a product of the current economic downturn, was that although technical innovation was recognized as being an important factor in enhancing the competitiveness of Alberta manufacturers, marketing, including product planning and development, were seen to be of a higher priority.

Industry identified several types of assistance required to support the use of modern manufacturing methods by Alberta manufacturers. Typical forms of assistance required included:

- marketing and product development;
- financial;
- assessing feasibility;
- evaluating and selecting systems; and,
- assistance in implementation.

Within the current infrastructure of government, academia and industry, there are available support programs which address some, but not all, of industry's needs. There is, however, a lack of awareness on the part of Alberta companies of those programs, primarily as a result of the absence of a significant marketing effort by the providers of the service(s). Furthermore, although support programs are available, there is no consolidated source of information available to industry to facilitate the identification of the most appropriate program to meet a specific need.

In addition to the lack of a consolidated source of information, several additional missing elements of support to Alberta industry were identified. These included:

- awareness-building programs, including access to a demonstration site;
- technical expertise to assist manufacturers in the assessment and implementation of advanced manufacturing technologies; and,
- access to tools such as factory simulation and modelling software, and prototype development equipment.

To ensure the cost-effective delivery of these critical services, while building on the strengths and capabilities of the existing infrastructure, a program encompassing the networking of resources in government, academia and industry is recommended. These resources are to be augmented by a core staff of technical and industrial specialists within the central organizing body.

When the concepts developed in the Phase I study are accepted, TRT and the ARC, in cooperation with the Canadian Manufacturers' Association (CMA), will undertake the second phase of the study. Phase II will focus on the development of the detailed Business Plan for the operation of the program.

II Background

Historically, the Alberta economy has been resource-based, with a strong dependence on oil and gas reserves. The strength of the resource-based economy peaked in the middle to late 1970's. Since then, Alberta has experienced two periods of economic downturn — one in 1982 and a second currently ongoing. As a result of the economic downturns, the importance of a diversified economy became evident. Manufacturing developed as a secondary industry, with a significant level of the manufacturing activity servicing the oil and gas industry. Today, manufacturing in Alberta represents a $4.6 billion sector, employing 80,000 people. Given the experience of the early 1980's and the current economy, the provincial government has seen wisdom in diversifying the industrial base of Alberta by supporting the Alberta manufacturers to further broaden the range of manufactured products and scope of markets served.

A key issue facing Alberta manufacturers is increasing competition from offshore manufacturers in domestic and international markets. Through the implementation of modern manufacturing technology, manufacturers in offshore countries have been able to improve the efficiency and effectiveness of the manufacturing process to the point where they are often able to manufacture high-quality products at a reduced cost. Accordingly, they have been successful in penetrating markets which have either, in the past, been serviced by Alberta manufacturers, or which represent future opportunities.

In order to successfully compete with offshore manufacturers, Alberta manufacturers must improve the efficiency, economies and quality of the manufacturing process to produce high quality marketable products. Part of the answer to this challenge lies in the development and implementation of modern manufacturing methods.

Alberta Technology, Research and Telecommunications (TRT) and the Alberta Research Council (ARC) are considering the establishment of a program or facility to assist Alberta manufacturers in using such technologies. TRT and the ARC have jointly undertaken Phase I of a two-phased study to determine which initiatives would make Alberta firms more competitive. Phase I of this study assesses the current status of the manufacturing technology in Alberta and identifies both the constraints and opportunities faced by Alberta manufacturers. Conclusions, based on a survey and focus group meetings with industry, recommend that TRT and ARC establish a program to assist Alberta firms in identifying promising markets and implementing advanced methods for product development and manufacturing.

Phase II of the study, to be undertaken following acceptance of the concepts developed in Phase I, will be directed towards the development of a detailed Business Plan for the operation of the program.

Touche Ross acknowledges the assistance of the Manecon Partnership and selected staff of the Industrial and Engineering Research Division of the Alberta Research Council in undertaking this assignment on behalf of Technology, Research and Telecommunications, and the Alberta Research Council.

III Objectives And Scope Of The Study

A. OBJECTIVES

The objectives of Phase I of the study are as follows:

- To determine the real needs of Alberta manufacturers for advanced manufacturing and product development technologies; and,
- To recommend appropriate means of accelerating the adoption of advanced manufacturing and new product development technology in Alberta.

B. SCOPE

The study dealt primarily with secondary and tertiary manufacturing, that is, those firms involved in the conversion of raw materials into finished products and the assembly of components into value-added products.

Several components of advanced manufacturing technology were considered during the survey:

- Production and inventory planning and control using microcomputer-based software;
- Computer-Aided design;
- Computer-Aided manufacturing;
- Numerical controlled machine tools, including NC (Numerical Controlled), CNC (Computer Numerical Controlled) and DNC (Direct Numerical Controlled);
- MRP (Materials requirements planning); and,
- Integrated design and manufacturing systems encompassing flexible manufacturing, materials handling and robotics.

IV Work Undertaken

The work program included the following activities:

- Reviewed relevant documentation related to advanced manufacturing technologies. The primary documents addressed in this regard were the *Final Report on An Assessment of Opportunities in Alberta Related to CAD/CAM Technology*, Dec. 1983 by Battelle, Nichols Applied Management, and the Alberta Microelectronic Centre; the *Man-Computer-Machine Interface Task Force Report* by the University of Alberta, May 1983; and the *Alberta Centre for Machine Intelligence and Robotics, A Proposal for Government Support* by the University of Alberta, Sept. 1986;
- Developed "contact list" and survey instrument to assess current status of Alberta manufacturing technologies and identify constraints and opportunities facing Alberta manufacturers in the development and implementation of such technologies;
- Conducted telephone interviews with 88 Alberta manufacturers. Ten companies declined to participate (their business was inappropriate because of size or product). Interviews were generally of 30-45 minutes duration and addressed such issues as:
  - description of the survey respondent, including number of employees, nature of products and processes, markets served and approximate annual sales revenue;
  - status of manufacturing technologies currently used;
  - if advanced manufacturing technologies were in place, benefits attributable to the technology, and process undertaken in the development and implementation of advanced technologies;
  - if advanced manufacturing technologies had not been developed/implemented by the survey respondent, identification of the constraints or barriers as perceived by the respondent;
  - identification of areas of assistance required by Alberta manufacturers to develop and implement the technologies; and,
  - perceived role of government, universities and technical institutes, and the Alberta Research Council in assisting industry.
- Conducted personal and/or telephone interviews with 17 additional companies identified by the Industrial Development Department, Alberta Research Council. The companies identified represented clients of the Department and included those companies which were thought to represent companies most likely to benefit from advanced manufacturing technologies. Six companies contacted by telephone were also visited. Accordingly, a total of 99 industry contacts were made. A list of Alberta manufacturers contacted is included in the Appendix;
- Conducted focus group sessions with the following groups:
  - Electronics Industry Association of Alberta (EIAA);
  - Selected Calgary manufacturers; and,
  - Selected Edmonton manufacturers.

Because of the limited sample size and our determination to get "face to face" interaction with industrialists, we used focus groups to elicit qualitative information that is suggestive rather than statistical.

EXHIBIT 1

NUMBER OF RESPONDENTS

Manufacturing Sector	Total		Number of companies using Advanced Manufacturing Technology	% firms in specific industry sector using Advanced Manufacturing Technology
	Number	% of Survey Sample		
1. Electronics	9	9	5	56%
2. Printing	4	4	2	50%
3. Food Processing	6	6	3	50%
4. Machine Shops	23	23	18	78%
5. Metal Fabrication	21	21	13	62%
6. Foundries, Structural Metal	12	12	3	25%
7. Wood Industries	6	6	3	50%
8. Furniture Manufacturing	8	8	2	25%
9. Plastics	4	4	1	25%
10. Miscellaneous	6	6	4	67%
Total	**99**	**100%**	**54**	**55%**

Work Undertaken *cont'd*

The purpose of the focus group sessions was to review the survey findings, present options for a supporting program or facility, and obtain industry feedback on appropriateness of alternative initiatives;

- Interviewed representatives of University of Calgary, University of Alberta, Northern Alberta Institute of Technology (NAIT), and Southern Alberta Institute of Technology (SAIT). A listing of individuals contacted is included in the Appendix;
- Interviewed government officials from the provincial government departments of Technology, Research and Telecommunications, Alberta Economic Development and Trade, and the federal government Department of Regional Industrial Expansion as identified in the Appendix;
- Interviewed representatives of Alberta Research Council, Industrial and Engineering Research Division;
- Conducted telephone interviews with representatives of selected industry associations (Appendix);
- Toured facilities and interviewed executives of other advanced manufacturing initiatives in Manitoba, Ontario and Quebec (Appendix);
- Developed and assessed alternative program and facility configurations to address industry's requirements as related to the development and implementation of advanced manufacturing technologies;
- Prepared and presented a final Phase I report to Research Committee of Technology, Research and Telecommunications and Alberta Research Council.

V Key Findings And Observations

In this section, we present the key findings of our discussions with Alberta manufacturers, government, universities and colleges, industry associations, and other advanced manufacturing centres.

A. ALBERTA MANUFACTURERS

1. The Survey Sample

We contacted the management of 99 Alberta manufacturers with operations in the industrial sectors as described in Exhibit 1. A complete listing of firms contacted is included in the Appendix. **65%** of the firms surveyed had **20 or more employees,** while **61%** of the companies contacted had annual **sales revenues in excess of $3.0 million.** The size (number of employees, annual sales revenues) of companies contacted during the survey is shown in Exhibit 2. 18% of the companies indicated that they were active in offshore markets, although export sales were generally less than 15% of total sales.

2. Current Status of Manufacturing Technology

Interviews with Alberta manufacturers indicated that the current status of advanced manufacturing technologies in Alberta can be characterized as follows;

- Generally, respondents were aware of the need for improving their competitiveness and the importance of advanced manufacturing methods in achieving this objective;

  but,

  those surveyed perceived new product development and expanded markets to be of a higher priority than general technical innovation. Most believed that technical innovation would naturally follow product and manufacturing requirements in response to market demand;
- Of the 99 companies contacted, 54 reported incorporating advanced manufacturing technologies of some form in the manufacturing process. Machine shops and metal fabricators were the predominant users of this technology, with approximately 70% of the companies contacted in these subsectors using the technologies. There was no significant difference in the utilization of advanced manufacturing technologies between the sample of 88 companies and the additional 17 "targetted" companies identified by the Industrial and Engineering Research Division, Alberta Research Council;
- Generally, however, the companies identified by the Industrial and Engineering Research Division demonstrated a greater awareness of the technology, its costs and benefits, and a greater willingness to consider the implementation of the technology in their company;
- Computer-Aided Design (CAD), Computer-Aided Manufacturing (CAM), Numerical Controlled (NC) and Computer Numerical Controlled (CNC) equipment represented the majority of advanced manufacturing

Key Findings and Observations *cont'd*

technologies in place in Alberta industry. It should be noted that of the technologies being used, Numerical Controlled should not really be considered as advanced technology, given its age. Robotics, Materials Requirements Planning (MRP) and Flexible Manufacturing Systems (FMS) were indicated as being used by only a few of the survey respondents. The number of survey respondents using specific components of advanced manufacturing technology is shown in Exhibit 3; and,

- **Although all survey respondents which had developed and implemented the technology indicated favorable results** in terms of increased productivity, reduced costs, improved product quality and reduced product development time, the equipment is not being used to maximum benefit. Manufacturers have purchased the equipment, but the skills and expertise required to make the equipment fully operational in an integrated system and realize the full benefits of integrated systems are lacking.

3. Assistance Required by Industry to Support the Application of Advanced Manufacturing Technology

The manufacturers contacted during the study identified several kinds of assistance as critical to successfully developing and using advanced manufacturing technology. The key needs of industry are described in this section of the report. Exhibit 4 summarizes the key needs and the frequency with which they are identified as a need.

Although almost all survey respondents recognized the importance of technological innovation, this was not considered to be the major issue facing Alberta manufacturers. Rather, as a result of the economic downturn in the oil and gas industry, the survey respondents identified marketing, including product planning and development to be the number one priority of industry. Specific marketing and product development assistance required includes:

i) *Marketing Assistance*

A key issue with respect to marketing is that Alberta manufacturers lack knowledge of potential markets for their products and, even when markets are identified, they are unsure how to access the markets. Marketing assistance, including market research studies to identify market opportunities, evaluate competitive products and provide input to the marketing and product planning process was identified as a key need. Marketing support mechanisms such as trade missions and the subsidization of costs incurred in marketing to export markets was identified as a requirement to support market expansion.

ii) *Product Planning and Development*

Interviews with Alberta manufacturers indicated that a major constraint to the product planning process is the limited vertical integration among Alberta manufacturers. Several survey respondents indicated that a lack of high quality raw materials, equipment, services and skilled people were constraints to the product planning, development and manufacturing process. Several participants in the focus group sessions indicated a need for Alberta manufacturers to consolidate their strengths and resources, and work as a "team" rather than as individual companies trying to meet all of their needs independently. Forms of assistance for the product development process include access to specialized equipment and expertise, and contract services in product planning, engineering, manufacturing and distribution.

Typical areas which many firms identified as requiring assistance in, to support the application of modern manufacturing methods, included:

i) *Financial Assistance*

Greater than 90% of survey respondents identified a need for financial assistance to subsidize the capital costs of advanced manufacturing technologies. With respect to financial assistance, manufacturers also require assistance in assessing financial risk as it applies to obtaining financial assistance from the financial institutions. Suggested forms of financial assistance programs identified by industry include grants, interest-free loans, and other cost-sharing programs to facilitate the acquisition of advanced manufacturing equipment, and to share the financial risk associated with such an investment.

ii) *Technology Evaluation*

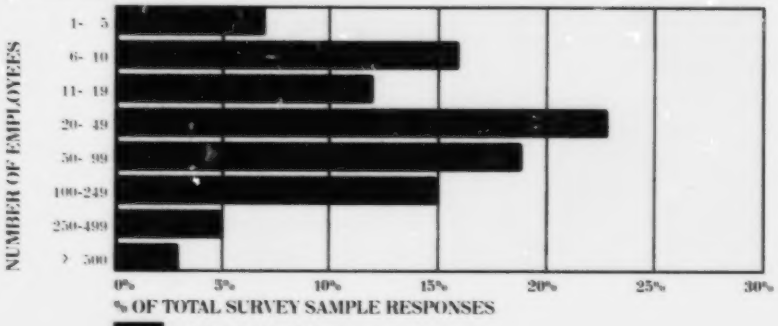
Corporate access to consultants and public laboratories with experience in advanced manufacturing technology in Alberta, is limited. Those survey respondents who have incorporated some aspect of advanced manufacturing technology reported using either in-house resources for hardware/software selection, or using services from eastern Canada and the United States. Concern was expressed that although there are several local vendors willing to sell the equipment, their advice is usually biased. External consultants were viewed by industry as not having sufficient depth in, and understanding of manufacturing.

Key Findings and Observations
cont'd

EXHIBIT 2

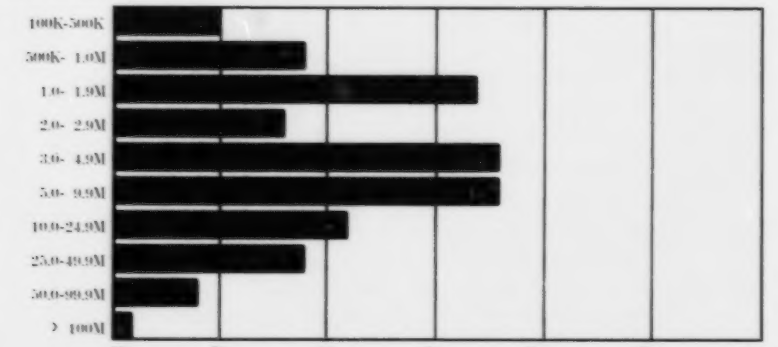
Analysis of Survey Respondents

NUMBER OF EMPLOYEES



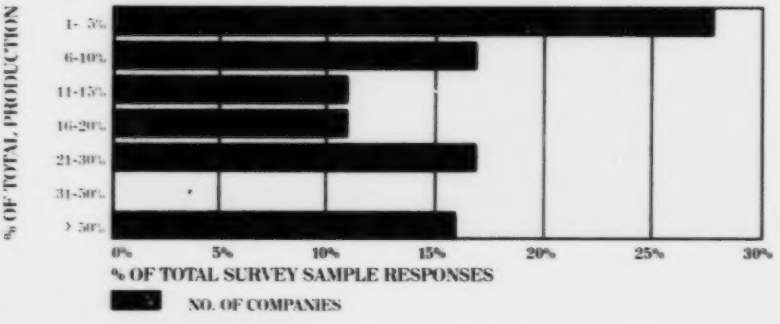
TOTAL SURVEY: 99
TOTAL RESPONSE: 86

ANNUAL SALES REVENUES



TOTAL SURVEY: 99
TOTAL RESPONSE: 77

EXPORT SALES



TOTAL SURVEY: 99
TOTAL RESPONSE: 18

iii) *Applications Support*

Representatives from industry identified a lack of local technical experience to provide applications support. Installing equipment and new methods on the shop floor is the first step of the implementation process. Expertise is needed for revising and refining the tools and organization, and for other support and maintenance requirements.

iv) *Information Sourcing*

Several manufacturers indicated that improved access to technical, marketing and business data bases would support the development and implementation of advanced technologies. Information considered to be useful in this regard included research and development, technical and patent information, location of local and remote suppliers, and identification of distribution and marketing services.

v) *Product Testing*

Accessibility to product testing facilities, *e.g.* structural analysis for welds on pressure vessels, was identified as a requirement to support the product development and manufacturing activities of Alberta companies. Access to selected component and product standards, *e.g.* Mil Specs, whether for testing or product compliance, was also identified as a need for industry.

4. Barriers or Constraints in the Development and Implementation of Advanced Manufacturing Technologies

Several local impediments constrain the development and implementation of modern manufacturing methods. These impediments included:

- senior management's resistance to heavy investment in technological change. Respondents were looking for a "quick fix" to their problems rather than

Key Findings and Observations
cont'd

committing to an organized and ongoing market research, product development and production engineering process. There was limited willingness (and capability) to invest capital in advanced manufacturing technologies and not realize a return on investment for 3-5 years;

- the perception of Alberta manufacturers that as small batch processors and small niche manufacturers, advanced manufacturing technologies are not appropriate to either their processes or products. This perception reflects the lack of awareness of the technology by Alberta manufacturers, as Flexible Manufacturing Systems (FMS) are designed specifically to meet the needs of small batch processors and offer significant opportunity for improvement in set-up time and product mix;
- limited technical skill to support development and use of advanced manufacturing methods. Although a few companies have some in-house resources, these are, in most cases, unavailable to other industry users; and,
- **little awareness of existing support programs. The provincial and federal governments, universities and colleges, and industry associations offer several support programs, but there is no consolidated source of information available to industry. Furthermore, there is confusion among the providers of the services and users of the services regarding the roles and responsibilities of government, universities, industries, and Crown laboratories.**

5. Resources Available to Alberta Manufacturers

In the previous two sections, we described the needs of Alberta manufacturers as identified through a survey of selected Alberta manufacturers and the constraints or barriers they face.

In this section, we identify selected resources currently available to industry. This section is not intended to be a comprehensive listing of assistance programs available to industry, but rather to identify selected programs which address industry's requirements in the following areas:

- financial assistance;
- assessment and implementation of technology;
- marketing and product development assistance; and,
- business/management assistance.

i) *Financial Assistance*

Several examples of financial assistance available to Alberta manufacturers include:

- Federal Government
  Department of Regional Industrial Expansion (DRIE) (Western Transportation Industrial Development Program);
- Provincial Government
  Alberta Research Council (ARC) Joint Research Venture Program;
  Alberta Economic Development and Trade (Market Development Assistance Program, Product Development Program, Loan Guarantee Program for Alberta Exporters, International Marketing Assistance Program);
- National Research Council
  Industrial Research Applications Program (IRAP);
- venture capital companies;
- Alberta Opportunity Company;
- Small Business Equity Corp.; and,
- tax-based incentives to undertake product research and development.

Financial assistance is currently available through the above organizations and agencies; however, it is not adequate to meet industry's requirements. There is limited funding for productivity improvement, manufacturing, engineering and to subsidize capital costs of equipment and facilities. Furthermore, a given source of funding will usually only support a *portion* of a total project, requiring that the company identify and contact several funding agencies. Companies do not have the time to seek out support programs.

Finally, there is little (if any) patient capital available to manufacturers. Financiers generally prefer investment in real estate or financial instruments, rather than manufacturing companies, given the potential higher short-term return of the former. As such, there is limited funding available to support corporate product development projects.

ii) *Assessment and Implementation of Technology*

There are several sources of technical assistance and training available to Alberta manufacturers. They include:

- technology centres established by the provincial government as part of an infrastructure to support industrial development;
- technical institutes and universities which offer practical training, education and, to a limited extent, consulting services and contract research;
- the national laboratory system of the National Research Council (NRC), including the Technology Inflow Program (TIP), provided jointly by NRC and External Affairs;
- provincial Crown laboratories, including the Alberta Research Council, Electronics Test Centre, Alberta Telecommunications Research Centre, etc.; and,

Key Findings and Observations
cont'd

- industry associations through workshops and seminars dealing with selected technical issues. These are generally local emerging industry associations, with some represented by a national association.

Few existing services deal specifically with advanced manufacturing technologies and, even in cases where they do, the services available are of a generic nature and do not actually apply the technical expertise to a *specific* corporate problem. Furthermore, the technical expertise available through these channels, with only a few exceptions, is remote from industry and does not address manufacturing or production problems.

iii) *Marketing and Product Development Assistance*

The federal government, with programs like the Program for Export Market Development (PEMD), supports the development of export markets. The Government of Alberta, through trade missions and the Market Development Assistance Program (MDAP), assists manufacturers in developing and servicing the needs of both domestic and offshore markets. With respect to assistance in product development, Alberta Economic Development and Trade provides the Product Development Program (PDP).

Industry associations support their membership in developing markets through networking suppliers and customers. This linkage encompasses suppliers and markets for finished products, as well as users and sources of raw materials, components, and research and development.

Finally, management consultants provide market research services on a project basis to manufacturers.

iv) *Business and Management Assistance*

There are a number of programs which help firms develop sound business principles, including financing, manpower planning and organization, and production and warehousing.

The Management Assistance Program (MAP) offered by Alberta Economic Development and Trade is an example of this type of assistance available through government.

The universities and technical institutes deliver programs to assist entrepreneurs, *e.g.* New Venture Development Program at the University of Calgary, and new venture programs to assist Alberta manufacturers in this respect. Municipally sponsored technology centres, *e.g.* Edmonton Research Park, Edmonton Economic Development Authority (EEDA), Calgary Advanced Technology Centre (CATC), the Calgary Research and Development Authority (CRDA) also provide entrepreneurial assistance to industry. Such services are also available through management consulting firms.

v) *Assessment of Existing Infrastructure*

In conclusion, resources are available to assist Alberta manufacturers in the development and implementation of advanced manufacturing technologies, but the delivery of services by these resources is less than optimal. Furthermore, the organizations responsible for delivery of programs that are relevant have not undertaken significant marketing efforts to generate industry's awareness of these programs. Generally, the expertise is remote from companies and deals with technology in general, rather than addressing corporate-specific manufacturing issues. Available services are not often well-known to companies. There is confusion among both the providers of the services and the users regarding their roles.

Although there are several support services available to industry, they function largely in an independent fashion. There is not a mechanism or organization established to coordinate the delivery of existing services to industry. Consequently, a company experiences difficulty when trying to obtain assistance or assemble a project team of external expertise to address a specific issue facing the company.

Critical services are not widely available to Alberta industry. It is these missing elements which must be addressed in the development of an initiative to assist Alberta manufacturers. These services include:

- **awareness building programs, including access to a demonstration site;**
- **technical expertise to assist manufacturers in the assessment and implementation of advanced manufacturing technologies; and,**
- **access to tools such as factory simulation and modelling software, and prototype development equipment.**

B. GOVERNMENT

Key findings of interviews with representatives of Alberta Technology, Research and Telecommunications, Alberta Economic Development and Trade, and the Department of Regional Industrial Expansion, Canada, are as follows:

- Provincial government organizations/agencies involved in delivering programs to assist Alberta industry include Alberta Technology, Research and Telecommunications, Alberta Economic Development and Trade and Crown laboratories such as the Alberta Research Council;
- Alberta Technology, Research and Telecommunications perceives its role in assisting the development of Alberta industry to be that of providing the infrastructure, information exchange, financial support and other assistance necessary to support technology development and commercialization of applied research;

Key Findings and Observations cont'd

- Alberta Economic Development and Trade perceives its primary role in assisting industry to include identifying the technical, market and product development needs of industry and developing/administering programs to meet these needs, providing funding support to assist local industry, and assisting Alberta manufacturers to identify and develop export market opportunities;
- The Alberta Research Council, through the services of the Industrial and Engineering Research Division, delivers NRC-supported programs (IRAP) to Alberta industry, and provides hands-on assistance in industrial engineering and problem solving through the Industrial Development Department (IDD).
- There was a general consensus that while the status of Alberta manufacturers in terms of manufacturing processes used and quality of products produced was improved, there is still significant opportunity for improvement. Many Alberta manufacturers are still unaware of the technology;
- Lack of industry awareness of modern manufacturing technology, a shortage of expertise to support the acquisition and implementation of modern technology, and a general lack of financial resources as a result of current economic conditions were identified as major impediments of Alberta manufacturers to using modern manufacturing technology;
- There is a consensus in government that any initiative to assist industry must be industry-driven to ensure that the specific needs of industry are met. Industry must, through either sponsorship, fee-for-service, or provision of manpower, be willing to support the program;
- In the past, government has committed significant funding to advanced technology initiatives, i.e.: Electronics Industry Information Centre ($1.6 million), Electronics Test Centre ($10.6 million), Biotechnology Toll Facility ($2.6 million), Supercomputing Services ($10 million), Telecommunications Research Centre ($3.6 million);
- In view of recent events in Ontario regarding the Ontario Centre for Advanced Manufacturing (OCAM) and other advanced manufacturing centres, the provincial government is developing and implementing a comprehensive program to evaluate the effectiveness and efficiency of existing advanced technology centres in Alberta:
  - i) Future centres must identify performance measures as they apply to industrial achievement and develop management and information systems to monitor and demonstrate the benefit to industry; and,
  - ii) Potential performance measures for programs in advanced manufacturing technologies may include the number of new products developed, improved productivity as measured by the per unit input *vs.* output, new markets services, and the creation/maintenance of employment opportunities.
- A two-phased approach to the delivery of assistance to Alberta manufacturers may be required:
  - i) Implementation assistance to those companies which are in a position to use modern manufacturing technology; and,
  - ii) Educational and awareness-building services to those companies which are unaware of the benefits and opportunities afforded by modern manufacturing technology.
- Government perceives that a phased approach by companies in the implementation of advanced manufacturing technologies is appropriate:
  - i) Companies must start with the basics and build as the needs and capabilities emerge; and,
  - ii) Basic industrial controls such as time measurement systems, inventory controls and production planning must precede any attempts to use modern manufacturing technology.

EXHIBIT 3

FREQUENCY OF ADVANCED TECHNOLOGIES IN ALBERTA MANUFACTURING INDUSTRIES

	NUMBER OF SURVEY RESPONDENTS USING THE TECHNOLOGY
Computer-Aided Design (CAD)	19
Computer Numerical Controlled (CNC)	10
Numerical Controlled (NC)	7
Computer-Aided Manufacturing (CAM)	7
Materials Requirements Planning (MRP)	3
Flexible Manufacturing Systems (FMS)	3
Direct Numerical Controlled (DNC)	1
Robotics	1

Key Findings and Observations *cont'd*

C. EDUCATION

Key findings of interviews with representatives of the University of Alberta, University of Calgary, Southern Alberta Institute of Technology (SAIT), and Northern Alberta Institute of Technology (NAIT) are as follows:

- Educators perceive that although certain manufacturers have made progress in developing and using modern manufacturing methods, there are significant opportunities for improvement;
- All universities and technical institutes in Alberta expressed an interest in working with industry towards the development and implementation of advanced manufacturing technologies;
- Universities perceive their role to be:
  - i) Education of students to the point where they can enter the workforce and function in an advanced technology manufacturing environment;
  - ii) Conduct research to ensure that state-of-the-art technology is available to select industries; and,
  - iii) Respond to special needs of industry, helping industry meet specific manufacturing problems.
- Perceived role of technical institutes (SAIT and NAIT) is to provide training and implementation assistance to industry;
- Both SAIT and NAIT expressed an interest in providing contract consulting and research services to industry and to some extent are doing so already;
- Training for individuals in advanced manufacturing is inadequate. Programs must be offered in product design, value engineering and manufacturing/ production engineering. The University of Alberta has recognized the requirement for improved technical and management training of individuals to support the implementation of advanced manufacturing technologies and will be offering a Management of Technology program given jointly between the Faculty of Business and the Faculty of Engineering. The University of Calgary offers Canada's only graduate program in Industrial Design. This program has a strong affiliation with the Faculty of Business and the New Venture Development Program;
- Both universities prefer a campus demonstration facility with proximity to university resources. The universities feel that there is a significant knowledge resource on campus which should be made available to industry. University representatives felt that a campus facility would improve relations with industry. Finally, a campus facility would be a valuable teaching tool;
- Universities perceive an on-campus facility established as a joint venture between management and engineering faculties to be the preferred option for a program or facility to assist Alberta industry;
- University management promoted a campus program or facility funded by totally new sources aside from the University budget. Potential sources of funding identified included the provincial government, the Alberta Research Council and the federal government through cost-sharing programs; and,
- University and industry people often disagree about goals and priorities. Job creation and economic diversification are not often considered high priorities by tenured university staff.

D. INDUSTRY ASSOCIATIONS

Key findings of discussions with representatives of industry associations are as follows:

- Generally, the industry associations contacted supported the establishment of some form of support mechanism to assist the manufacturing industry;
- While moral support for such an initiative was expressed, financial support was generally nonexistent;
- Reduced sales and subsequent lack of funds to support capital investment in equipment is perceived to be a key constraint to the implementation of advanced manufacturing technologies;
- A source of information on products and markets to support the diversification of Alberta industry is a key requirement of the manufacturing industry;

EXHIBIT 4

INDUSTRY ASSISTANCE NEEDS

	% OF SURVEY RESPONDENTS INDICATING ITEM AS AN INDUSTRY NEED
Financial Assistance	90%
Marketing Assistance	60 - 70%
Product Development Assistance	60 - 70%
Assessment and Implementation of Technologies (Technology Evaluation)	60 - 70%
Post Implementation Applications Support	25 - 40%
Information Sourcing	25 - 40%
Product Testing	25 - 40%

Key Findings and Observations
cont'd

- The Canadian Manufacturers' Association (CMA) perceived that the area in which manufacturers require the greatest assistance is marketing;
- The CMA believes that overall, the manufacturing industry will benefit if industry leaders take the initiatives to be more competitive and export market-oriented. Further, it is the responsibility of the industry leaders to provide training to managers of smaller companies, assist them to find markets, and encourage the companies to take up new technologies in order to do business with the leaders; and,
- Finally, the CMA recognized a requirement for Alberta manufacturers to move from a service-oriented job shop manufacturing industry to an outwardly focussed product-oriented industry.

E. EXPERIENCE OF OTHER ADVANCED MANUFACTURING INITIATIVES

In this section of the report, we describe key aspects of the operations of other selected advanced manufacturing initiatives or centres. While not all of the facilities or programs visited necessarily demonstrated the identified characteristic, the following features were the most important and useful to factor into a program in Alberta.

A key characteristic of several of the centres is that the programs they offer to industry are directed to solving industry problems through the *application of technology in a production environment*. This differs from the "Centre of Excellence" approach, in which a facility is established for the purpose of the development of leading edge advanced manufacturing technology, through research and development initiatives. The former approach is preferred, as it is only through the direct application of advanced manufacturing technologies to corporate-specific problems that industry recognizes the benefits of the technology and achieves corporate goals.

In order for a centre to effectively operate in this mode, industry must be aware of the opportunities and benefits presented by the technology. Accordingly, most centres conducted *awareness-building seminars and workshops* to generate industry's interest in the technology. Typically, these seminars addressed the services and programs available, opportunities and benefits presented by advanced manufacturing technologies, and typical projects which have been undertaken on behalf of industry. In some cases, demonstration projects are a major component of awareness-building programs.

The centres generally offer *services in three key areas* to meet the needs of industry:

- Needs assessment and opportunity identification;
- Feasibility studies; and,
- Implementation assistance.

The objective of this service "package" is threefold:

- To ensure that the appropriate technology is selected to meet a specific company's needs and that the technology is appropriate to the company's products and processes;
- To ensure that there is a "business case" for the development and implementation of advanced manufacturing technologies given current and forecasted production and sales volumes; and,
- To support the company in the installation and operation of the equipment to ensure that maximum benefit is derived from the technology.

The following activities or services are generally not offered by the centres to industry:

- Funding assistance to industry;
- Research leading to the development of new technologies; or,
- Service bureau services.

Most centres operate on a *fee-for-service basis*, with the fee consisting of a combination of charges for materials used and labor. The revenues generated through the delivery of services partially offset the capital and operating costs of the centre. Most centres of this kind felt that charging fees for their services increased the perception that the services had value.

To ensure that the facilities have the collaboration and support of other stakeholders in advanced manufacturing technologies, and to ensure that clients of the centres have access to available resources, the centres *involved universities and vendors in the development and delivery of programs* as appropriate. Universities and colleges supplement the education and training programs of the centres, while the vendors were involved in the establishment of demonstration facilities.

As the credibility and success of the centres are dependent upon industry involvement, almost all of the centres had some form of a *proactive marketing program*. The Ontario Centre for Advanced Manufacturing (OCAM) for example, operates a client services group and had 1986 marketing and communication expenditures of approximately $750,000.00 out of a total $10.2 million expenditures. Industry cannot be expected to seek out the services of such a centre on their own, but rather must be made aware of the services and facilities available, and how such services and facilities apply to their specific situation. Furthermore, as the revenue generated by the centre is a function of the level of industry use, the undertaking of a proactive marketing program will ensure that the financial burden of operating the centre to funding agencies other than industry will be minimized. Typically, the proactive marketing programs include such activities as awareness-building seminars, plant visits, and the publication and distribution of case studies, technical reviews or

Key Findings and Observations *cont'd*

announcements of the centres' activities. OCAM, for example, produces a videotape of each successful project, which is made available to interested companies for viewing.

Finally, and most importantly, all the centres visited indicated a requirement for the programs and services delivered to industry to be *responsive and flexible* to accommodate changes in industry's needs. This is best demonstrated by the experience of OCAM. When OCAM was first established, industry lacked awareness of advanced manufacturing technologies and the opportunities presented. Accordingly, a major component of OCAM's activities was the delivery of awareness-building seminars and workshops. As industry moved up the learning curve, however, the requirement for seminars and workshops decreased. As a result, OCAM shifted the focus of its activities towards implementation assistance.

F. CONCLUSIONS

Based upon interviews with selected Alberta manufacturers, the following conclusions regarding the establishment of a supporting infrastructure for the development and implementation of advanced manufacturing technologies can be drawn:

- Although industry recognized that *technological innovation* is necessary to some degree if Alberta manufacturers are to produce a better quality product, increase productivity, and compete successfully in domestic and offshore markets, *product development* and the *identification and accessing of new markets* were identified as higher priority needs of Alberta manufacturers. The sequence, as described by industry, is questionable, as innovation and market demand are intimately connected. The key issue is that Alberta manufacturers are to be encouraged to use modern technology, but based on product development and market needs, rather than for the sake of technology per se;
- Several Alberta manufacturers have purchased advanced manufacturing equipment of some sort, but the industrial and production engineering skills and expertise to make the equipment fully operational in an integrated manner are lacking. As a result, full benefits of the technology are not being realized and productivity and product quality are not optimal. Industry requires assistance in planning and implementation of integrated manufacturing methods. The provision of funds alone to assist industry in the acquisition of the equipment is not sufficient. Assistance must be provided to ensure that the funds are used to acquire appropriate manufacturing technology, and that the technology is used in a manner which provides maximum benefit to industry;
- The implementation of modern manufacturing technologies represents an opportunity for improvement in the competitiveness of Alberta manufacturers, as such technologies will lead to:
  - i) higher quality and more marketable products;
  - ii) enhanced productivity;
  - iii) timely product development; and,
  - iv) improved control.
- Alberta manufacturers appear to lack a focussed corporate strategy for product development. While the survey respondents discussed the issues of new capital equipment requirements and the need for expanded or new markets, there was no mention of corporate strategy and the need for an ongoing product development process within firms;
- There are currently support programs available to industry in areas of financial, technical, marketing and business assistance, but the resources are scattered, remote from industry, and address industry problems from a generic rather than a corporate-specific perspective. Services to address corporate-specific product planning and development, manufacturing and marketing issues are available in limited measure. Scattered and remote programs require firms to spend valuable time seeking out assistance from a variety of government agencies, associations and individuals;
- There is confusion among both the providers of services and users of services regarding the role of government, universities and technical institutes, industry associations and the Alberta Research Council. Industry requires assistance in identifying and contacting the appropriate organization to meet specific needs;
- Although support programs are available to industry to address specific business, technical and marketing needs, critical services are not being delivered. Specifically, Alberta manufacturers do not have ready access to technical expertise, vendors, external consultants or demonstration facilities, to enable industry to first access the applicability of advanced manufacturing technology to corporate-specific products or processes, and secondly, to assist in the implementation of the technology; and,
- **There are two critical needs of Alberta manufacturers to be met by the proposed initiative:**
  - **i) delivery of critical services currently not available to industry; and,**
  - **ii) an integrated and coordinated approach providing access to existing and proposed business services.**

VI Program Requirements

In this section of the report, we describe key requirements which must be met by the proposed program or facility if it is to be successful in assisting Alberta manufacturers to be more competitive in domestic and international markets through the development and implementation of advanced manufacturing technologies. There are two categories of requirements discussed:

- Critical success factors which describe selected aspects of the program's or facility's operations, and which *must* be met if the initiative is to be successful; and,
- Services to be delivered by the program or facility to meet industry's needs.

A. CRITICAL SUCCESS FACTORS

1. Program or Facility must be Industry-Driven

To be effective in enhancing the competitiveness of Alberta manufacturers in domestic and international marketplaces through improved productivity and the manufacture of a better quality product, the program or facility must deliver services to address corporate-specific production issues. Accordingly, services should be delivered through the undertaking of *industry projects*, with the objective of each project being the achievement of corporate-specific goals and industrial achievement. This objective can only be met through the *application of technology* to address industry's problems, and not through the undertaking of research activities directed towards the development of new technologies.

To ensure industry's commitment to the program, a sponsorship, fee-for-service or a program under which industry provides the manpower to the initiative must be implemented. Furthermore, the success and credibility of the program or facility will not be measured in terms of selected internal performance parameters, but rather in terms of industrial achievement measured as the number of new products developed, industry productivity and new markets developed.

2. Marketing

The development and implementation of a proactive marketing approach is required because the program or facility depends on industry awareness and involvement, *i.e.* industry involvement is a measure of success for the program.

A high use of the facility by industry, under a competitive fee-for-service schedule, will provide a revenue base to offset the capital and operating costs of the facility. These revenues, supplemented by an increased tax base as industry grows, will support the operation of the program or facility in a fiscally responsible manner, with a minimum financial burden to government.

Furthermore, the greater the industry awareness of the program, the greater the potential for involvement with industry, and the greater the opportunity for the program or facility to gain credibility through industrial achievement.

Components of the marketing program may include:

- seminars and workshops;
- plant visits; and,
- publication of case studies, product tests and announcements.

Marketing materials may address the following:

- benefits of advanced manufacturing technologies;
- applicability of advanced manufacturing technologies to a wide range of products and processes; and,
- services and facilities available through the proposed program to assist a company in the assessment and implementation of advanced manufacturing and design technologies.

3. Strong Technical Expertise and Credibility

The program must be able to address and solve complex technical problems faced by industry. Accordingly, the staff must include individuals with the following specific expertise and experience:

- expertise in a manufacturing and production environment, with a working knowledge of manufacturing technologies and issues;
- specific experience in industrial subsectors to which the services of the program or facility are to be targetted;
- hands-on experience in the assessment and implementation of advanced manufacturing technologies; and,
- ability to market the services to industry to ensure industry awareness and use of the technical expertise and equipment available through the program or facility.

This expertise may be made available to industry through a minimum level of staff retained as a core group, augmented by expertise seconded from industry, government and universities/colleges on an as-needed basis.

The program staff must demonstrate a familiarity with industry's problems, and be able to work closely with companies towards the achievement of corporate goals. Accordingly, the staff must be action-oriented, with services being directed towards the *implementation of technology* rather than the undertaking of research activities to support technology development.

4. Credibility of Demonstration Capability

A key function of the proposed program or facility is to provide industry with access to working models of the technology to enable companies to assess the applicability of the technology to corporate-specific

Program Requirements *cont'd*

products and processes. This function may be delivered through the establishment of demonstration sites in production environments by undertaking projects with selected Alberta manufacturers.

All demonstration capabilities of the program are to be in industry, as the credibility of the technology will best be established through the application of the technology to specific manufacturing problems. To maximize the credibility of demonstration capability and meet industry's information needs, selection criteria for the location of the demonstration capability must be established. These criteria may include:

- leadership position of the company in terms of product development, technological innovation and markets served; and,
- selection of manufacturers as demonstration sites, such that several industry subsectors, *e.g.* metals, plastics, wood industries, etc., are represented.

The benefit of establishing demonstration facilities extends beyond that of providing the infrastructure for plant tours. By providing a facility which addresses the manufacturing problems of a specific company, there are long-term economic benefits to be realized. The demonstration facility program, through investment in a company, will effectively provide the company with the capability to better address product and market requirements in-house, rather than seeking the services/products of other facilities or suppliers which may be out-of-province. As such, over the long-term, the tax base of Alberta should grow.

5. Delivery of Selected Services

As stated previously, the program or facility must operate in a fiscally responsible manner, with a minimum financial burden to government. Accordingly, the program or facility must not deliver redundant services, but rather complement existing infrastructure and resources building on capabilities already in place, and deliver critical services currently not available.

In order for the program or facility to effectively meet the needs of industry, it cannot be "all things to all people." Should it attempt this strategy, the quality and focus of services, by virtue of funding constraints, will be "diluted," such that the program or facility will be seen by industry as not having technical expertise or credibility in any specific aspect of advanced manufacturing technology. Rather, it must offer selective incremental services, currently not available, for which it has the required expertise in-house (execution), and coordinate existing resources on a project-by-project basis (referral).

B. SERVICE REQUIREMENTS OF INDUSTRY

As stated previously, the success and credibility of the proposed program or facility are dependent upon the initiative meeting industry's needs. Accordingly, in this section of the report, we reiterate industry's needs as identified during discussions with selected manufacturers.

Key service requirements of Alberta manufacturers include:

- **financial assistance** in the form of grants, loans, or other programs to subsidize the capital costs and share the financial risks associated with the acquisition of advanced manufacturing technologies;
- **technical assistance** in the assessment, selection and implementation of advanced manufacturing technologies;
- **marketing assistance,** encompassing market research studies, to identify and evaluate new markets, identify product requirements, assess competition, develop the components of a marketing plan, and financial assistance in accessing new markets;
- **contract research and production management advisory services** to provide industry with access to specialized expertise and equipment to meet engineering, product development and design, manufacturing, and marketing requirements;
- **technical, marketing and business information data bases;** and,
- **post implementation applications support,** including servicing and maintenance of advanced manufacturing hardware and software.

Appendix A

SURVEY PARTICIPANTS

Alberta Technology, Research and Telecommunications and the Alberta Research Council wish to extend their appreciation to all those who took part in the "Advanced Manufacturing in Alberta, Needs Assessment Study," Phase I, including:

ALBERTA MANUFACTURERS

ELECTRONICS

Beta Monitors & Controls Ltd.
Canutel Industries Ltd.
EDO (Canada) Ltd.
Interalia Inc.
Northern Telecom Canada Limited
Novatel Communications Ltd.
Palco Telecom Ltd.
Polestar Communication Ltd.
Q-Tron Ltd.

FOOD PROCESSING

Canada Packers Inc.
Capital Packers Ltd.
Centennial Packers Ltd.
Dvorkin Meat Packers Ltd.
Facchin Foods Co. Ltd.
Labatt's Alberta Brewery
St. Paul Beverages Ltd.

FOUNDRIES AND STRUCTURAL METAL

Airdrie Springs
Alberta Walker Wellheads, Walker Steel Corp.
Fairmount Electroplating Western Ltd.
Industrial Wire & Iron Works
Interprovincial Steel & Pipe Corp.
Irving Industries, Foothills Steel Foundry Division
Lethbridge Ironworks Company
M.A. Steel Foundry Ltd.
Northern Steel Inc.
Norwood Foundry Ltd.
Stelco Inc.

FURNITURE MANUFACTURERS

Artmet Products Ltd.
F D Y Furniture (Mfg) Ltd.
Flo-Form Industries (Alberta) Ltd.
Palliser Furniture Ltd.
Simo Dow Mfg. Limited
SMED Manufacturing Inc.
Superior Furniture Systems
Westwood Manufacturing Ltd.

MACHINE SHOPS

Apollo Machine & Welding
Ardco Industries Ltd.
Canadian Foremost Ltd.
Canadian Pacific, Ogden Industrial Yard
Dover Corporation of Canada Limited
Dresser Clark Division, Dresser Canada, Inc.
George & Nick's Machine Works Ltd.
Hiltap Fittings Ltd.
Hydril Canadian Co. Ltd.
Independent Machinery Ltd.
Legrand Industries Ltd.
National Supply Canada, Division of ARMCO Canada Ltd.
Northwest Industries Ltd.
Nutron Manufacturing Ltd.
Oil Patch Group Inc.
OPSCO Industries Ltd.
Precimax Mfg. Ltd.
Quinn's Oilfield Supply Ltd.
Standen's Limited
Stream-Flo Industries Ltd.
Vertec Industries Ltd.
Volk Industries Ltd.
Wemas Industries Ltd.

METAL FABRICATORS

Altank Industries Ltd.
Atco Metal (Div. of Atco Ltd.)
Barber Industries
CESSCO Fabrication & Engineering Ltd.
Dreco Ltd.
Gienow Building Products Ltd.
Grain Guard Mfg. & Sales Ltd.
Jager Industries Inc.
J.H. Lock & Sons Ltd.
Liberty Boilers (1982) Ltd.
Natco Ltd.
Porta-Test Systems Ltd.
Propak Systems Ltd.
Sarman Custom Metal Fabrications Ltd.
Sprung Instant Structures Ltd.
Universal Industries Ltd.
Westeel-Rosco Ltd.
Western Rock Bit Co. Limited
Western Steel Fabricators Alberta Ltd.

PLASTICS

Amptech Corporation
Modern Packaging Co. (1984)
Spencer-Lemaire Industries Ltd.

PRINTING AND BUSINESS FORMS

Craftsman Printing & Graphics Ltd.
Lawson Business Forms Alberta Ltd.
Mcara Printing Ltd.
Pro Forms Ltd.

WOOD INDUSTRIES

A.B. Cushing Mills Ltd.
Blue Ridge Lumber (1981) Ltd.
Canadian Forest Products Ltd.
Edmonton Millwork Ltd.
Evans Brothers Custom Woodwork
Mountainview Industries

MISCELLANEOUS

Banner Gelatin Products (Canada) Ltd.
Endura Manufacturing Co. Ltd.
General Systems Research Ltd.
Glenmore Sailboats Ltd.
Silver-Glo Picture Tube Ltd.
Tower Paint & Laboratories Ltd.

UNIVERSITIES & TECHNICAL COLLEGES

Northern Alberta Institute of Technology
Southern Alberta Institute of Technology
University of Alberta
University of Calgary

GOVERNMENT OFFICIALS

Alberta Economic Development and Trade
Alberta Technology, Research and Telecommunications
Federal Government Department of Regional Industrial Expansion

INDUSTRY ASSOCIATIONS

Alberta Forest Products Association
Calgary Research and Development Authority
Canadian Manufacturers' Association
Edmonton Council for Advanced Technology
Electronics Industry Association of Alberta
Machinery and Equipment Manufacturers' Association of Canada

OTHER ADVANCED MANUFACTURING INITIATIVES

Canadian Institute for Industrial Technology, National Research Council, Winnipeg
Canadian Institute for Metalworking, Ancaster, Ontario
Centre de Recherche Industrielle de Québec
Industrial Technology Centre, Winnipeg
Manitoba Research Council, Winnipeg
National Research Council, Mechanical Engineering Laboratories, Ottawa
Ontario CAD/CAM Centre, Cambridge
Ontario Centre for Advanced Manufacturing, Rexdale
Ontario Research Foundation
Ontario Robotics Centre, Peterborough